Numerical analysis of pulsed local plane-wave generation in a TREC

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***Abstract*— The feasibility of generating arbitrary wavefronts within a time-reversal electromagnetic chamber (TREC) has been demonstrated both theoretically and experimentally. Though originally motivated for EMC tests, the generation of coherent wavefronts within a reverberating cavity has a potential interest in antenna testing, too. In this paper, the generation of locally planar wavefronts is addressed by means of numerical simulations involving a 2D cavity, for a scalar electric field. The relationship between the quality of the wavefronts and its defining parameters (bandwidth, curvature, phase center, etc.) is investigated.**

Keywords-component; wavefront synthesis, test facilities, time reversal, TREC, electromagnetic pulses.

I. Introduction

The ability to generate deterministic wavefronts is fundamental in any test facility aiming at characterizing how a device under test (DUT) responds to electromagnetic energy. This need ranges from EMC applications to radar imaging, passing through antenna tests. The common point in all of these scenarios is the presence of locally-planar wavefronts, with features such as polarization, direction of arrival, bandwidth, etc., that are preliminary defined. The simplest approach implies the use of anechoic environments (anechoic chambers, OATS, TEM cells, etc.) where a source (or a collection) generate a far-field distribution appearing as locally planar in the proximity of the DUT. Though of simple interpretation, the implementation of this technique can be quite cumbersome when a large number of incidence angles are required, particularly in the case of complete 3D characterization, because of the need of complex mechanical displacements. An alternative approach, using fixed sources, but without involving distributed multiple sources is the TREC.

II. The Time-Reversal Electromagnetic Chamber

The TREC is a test facility based on the properties of time-reversed wavefronts and the propagation of waves in diffusive media [1,2]. In its original form it consisted of a reverberating cavity, driven at frequencies where it can support a diffuse field configuration, where the electromagnetic field can be well represented by a random incoherent field distribution, totally depolarized. Time-reversed signals naturally lead to spatial coherence functions of the field. They thus provide the ability to generate deterministic wavefronts, with a spatial resolution limited by the average spatial-coherence cells of the medium [3], i.e., about half a wavelength. Target wavefronts can thus be defined for a virtual source, and time-reversed to converge onto its phase-center. The main interest of this procedure is that the use of an isotropic diffusive medium implies that any direction of arrival can be generated without needing the line-of-sight conditions required by free-space like environments.

Results from numerical simulations will be provided in this respect, showing how the physical dimensions of the TREC cavity and the bandwidth of the test signals impose a lower bound to the phase precision of the planar approximation, as well as its amplitude uniformity. A scalar electric field configuration will be considered, by means of a quasi-2D cavity. Conclusions will be given with respect to the design of DUT testing in a TREC.

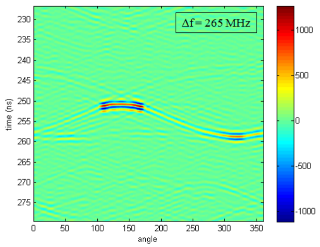

Figure 1. An example of pulsed wavefront generated by a TREC, for a central frequency of 1 GHz and a bandwidth of 265 MHz.The dominant parts of the wavefronts are the incoming and outgoing waves crossing a circular array of field probes.

References

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